Grassland Savannah Rangeland Ecosystems

© Jack Hewson / Kenya

The Importance of Grasslands, Savannahs and Rangelands in Global Climate Change Strategies

Key Recommendations:

Grasslands, savannahs and rangelands (GSRs) are huge carbon stores, vital global resources for biodiversity, food and freshwater security, and offer many ecosystem services to support climate mitigation and adaptation. High biodiversity GSRs generally have the greatest mitigation and adaptation benefits. Parties to the UNFCCC are therefore urged to:

- Ensure the protection, sustainable management and restoration of natural GSRs in adaptation plans and Nationally Determined Contributions (NDCs)
- Protect natural GSRs from land use changes such as inappropriate afforestation and agricultural intensification, which lead to net losses of carbon stocks, biodiversity and other ecosystem services
- Align UNFCCC actions on GSRs with the CBD and UNCCD, including through National Biodiversity Strategies and Action Plans (NBSAPs) and Land Degradation Neutrality (LDN) targets.

The companion document "Grassland Savannah Rangeland Case Studies of Significance for Carbon and Biodiversity" is also available and provides several examples giving context to the state of GSR carbon studies and projects around the world.

This is a jointly produced briefing from WWF-International and Plantlife International for country delegates at COP27.

Plantlife

Equilibrium RESEARCH

WWF

Grasslands, savannahs and rangelands contain huge carbon stores to mitigate climate change and provide ecosystem services that help adapt to a changing climate

GSRs sequester carbon,[1] with the large majority stored below ground in roots and soil organic carbon (SOC).[2] Their huge extent means their carbon stocks are vast: rangelands alone account for 54% of global land;[3] recent figures for grasslands suggest they store between 25-35% of terrestrial carbon,[4,5,6] 90% of it underground.[7] Statistics are hampered by lack of agreement about where GSRs merge into forests and wetlands,[8] and by variations in sequestration and storage between GSR types.[9,10,11] Whilst GSRs store less carbon per area than forests, their underground stocks are considered safer in areas of high fire or future logging risks.[12]

GSRs are also essential but under-valued[13] assets in adapting to present and future climate change. Healthy grassland ecosystems reduce soil erosion, dust storms and desertification,[14] and protect against flooding.[15] GSRs aid water security through protection of surface and groundwater sources;[16] support food security and livelihoods through livestock production, pollinators and wild foods;[17] and maintain a wide range of recreational,[18] cultural and aesthetic benefits.[19,20]

GSR ecosystems can play a key role in government responses to climate change under the UNFCCC, both in Nationally Determined Contributions (NDCs) and in adaptation plans.

Benefits can be achieved both by maintaining or restoring natural, old-growth grasslands,[21] and by changing agricultural practices and livestock management,[22] such as through wider use of silvopastoral systems.[23] However, at present few countries include GSRs in their approaches. Analysis in 2019 found only 10% of NDCs mentioned grasslands, with most of these being in Africa. [24]

The dense underground root structure of grasslands is how they store and fix most of their carbon below ground

But these ecosystems are increasingly vulnerable and threatened

GSR carbon stores require effective management to prevent emissions from soil disturbance, land-use change and degradation, including from overgrazing or encroachment of woody biomass or invasive grasses.[25] Some non-native, invasive and fire-adapted grasses increase fire risk in ecosystems not adapted to fire, releasing more carbon.[26] Yet natural grassland is often undervalued in conservation policies;[27] indigenous temperate grasslands are the least protected terrestrial biome;[28] 90% of temperate grasslands have already been converted to agriculture and urban areas, and less than 1% of the remnants are currently protected from land development.[29] Climate change itself can exacerbate these losses. For instance, increased variation in precipitation in dryland areas is predicted to decrease grassland productivity[30] and cause longer, more severe droughts. This can reduce soil carbon sequestration due to decreased plant litter inputs and increase CO2 emissions from soils. Elevated CO2 also favours woody species, exacerbating woody encroachment. Increased grassland plant species diversity can help to mitigate many of the effects mentioned above.[31]

Ironically, some climate change mitigation strategies can themselves drive biodiversity and carbon losses from GSRs

Forest conservation actions have at times displaced land use change into biodiverse GSRs, e.g., in Brazil,[32] China,[33] and the Congo Basin.[34] Degraded grasslands, savannahs, and natural grasslands mistaken for degraded forests have been inappropriately planted with trees.[35] Such tree planting destroys underground carbon stocks and grassland community composition which may take centuries to recover.[36] Problems could be aggravated by efforts to meet UNFCCC goals,[37] if forest "restoration" occurs in natural or semi-natural grasslands[38] or savannahs,[39] with important flora and fauna.[40] Forest restoration targets of the Bonn Challenge have encouraged some governments to focus on quantity of trees rather than quality of forests.[41] Identification of suitable reforestation areas, e.g., by the World Resources Institute,[42] have been criticised as including important grassland areas.[43]

Increasing native tree cover is essential for carbon sequestration and conservation, but must be guided by the principle of 'right tree, right place' and not achieved at the expense of other carbon and species-rich habitats.

The temperate grasslands of Russia's far east; the least protected terrestrial biome, 90% of temperate grasslands have been converted to agriculture and settlement.

Climate change and biodiversity loss must be tackled simultaneously in GSRs

Natural GSRs support high levels of biodiversity, including many threatened species. There is also evidence that biodiverse GSRs have greater resilience in the face of environmental change.[44,45] Restoration of GSR biodiversity accelerates soil carbon sequestration in some conditions.[46,47] Protection of SOC is therefore most effective if combined with biodiversity conservation,[48,49] creating synergy between aims of the Convention on Biological Diversity and the UNFCCC. Restoring native wildlife, in particular re-establishing grazing herds, can help to: maintain the light-absorbing albedo effect of GSRs and their potential as carbon sinks; maintain peat soils under permafrost; and restrict above ground woody biomass to reduce carbon released from natural burning.[50] Research from the Serengeti-Mara found an increase of 100,000 wildebeest translated to approximately 10% less area burned.[51]

Climate change mitigation therefore needs to be aligned with other objectives linked to biodiversity.[52]

A narrow focus on carbon can undermine biodiversity.[53] Research in the Brazilian Cerrado found that artificially suppressing fire beyond natural levels increased carbon sequestration by allowing more woody growth, but caused a decline in savannah plant and ant species.[54] Other research shows that prioritising both biodiversity and soil carbon can achieve up to 90% of each objective, triple conservation gains and halve implementation costs.[55]

Knowledge of co-benefit areas with high biodiversity and high carbon can help in the identification of NDCs.[56]

A combination of protection, sustainable management and restoration can maximise the potential of GSRs in climate change strategies

Due to their existing high underground carbon stocks, protection of the remaining ancient grasslands is a first priority for GSR climate mitigation,[57,58] especially vulnerable sites with more-or-less irrecoverable carbon.[59] Restoration actions focusing on building back old-growth characteristics can facilitate further carbon sequestration and storage in GSRs. These may include suppressing invasives and woody encroachment, vegetative propagation, establishing bud banks and below-ground organs,[60] temporary grazing exclusion,[61,62] reduced livestock grazing,[63] rotational grazing,[64] changed cropping patterns, enhanced grassland biodiversity and early season burning.[65] Sustainable management reduces emissions of methane, another greenhouse gas.[66] GSR management and restoration also reverses biodiversity decline, protects ecosystem services, e.g., reduced soil erosion,[67] while also preserving the livelihoods and cultural traditions for the 800 million people[68] living in GSRs. Many conservation strategies can be integrated with traditional practices, such as where floristic quality, richness and diversity are increased by sustainable grazing management.[69]

A specific focus on grasslands, savannahs and rangelands in NDCs and national adaptation plans is therefore now an urgent priority.

References

1. Conant, Richard T. 2010. *Challenges and opportunities for carbon sequestration in grassland systems*. FAO, Rome
2. Lal. 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science* **304**: 5677.
3. ILRI, IUCN, FAO, WWF, UNEP and ILC. 2021. *Rangelands Atlas*. ILRI, Nairobi Kenya.
4. White, R.P., Murray, S. and Rohweder, M. 2000. *Pilot analysis of global ecosystems. Grassland ecosystems.* World Resources Institute, Washington DC.
5. Royal Society, 2001. The role of land carbon sinks in mitigating global climate change. Policy Document 10/01. London.
6. Bai, Y. and Cotrufo, M.F. 2022. Grassland soil carbon sequestration: Current understanding, challenges and solutions. *Science* **377**: 603-608.
7. Bai, Y. and Cotrufo, M.F. 2022. *Op cit.*
8. Dixon, A.P., Faber-Langendoen, D., Josse, C., Morrison, J. and Loucks, C.J. 2014. Distribution mapping of world's grassland types. *Journal of Biogeography* **41** (11): 2003-2019.
9. Scurlock, J.M.O. and Hall, D.O. 1998. The global carbon sink: a grassland perspective. *Global Change Biology* **4**: 229–233.
10. Rees, R.M., Bingham, I.J., Baddeley, J.A. and Watson, C.A. 2005. The role of plants and land management in sequestering soil carbon in temperate arable and grassland ecosystems. *Geoderma* **128**: 130–154.
11. Schuman, G.E., Janzen, H.H. and Herrick, J.E. 2002. Soil carbon dynamics and potential carbon sequestration by rangelands. *Environmental Pollution* **116:** 391-396.
12. Dass, P., Houlton, B.Z., Wang, Y. and Warlind, D. 2018. Grasslands may be more reliable carbon sinks than forests in California. *Environmental Research Letters* **13:** 074027.
13. Bengtsson, J., Bullock, J.M., Egoh, B., Everson, T., O'Connor, T. et al. 2019. Grasslands – more important for ecosystem services than you might think. *Ecosphere* **10** (2): e02582.
14. Al-Dousari, A.M. 2009. Recent studies on dust fallout within preserved and open areas in Kuwait, In: *Desertification in Arid Lands: Causes, consequences and mitigation* (eds.) Bhat, N.R., Al-Nasser, A.Y. and Omar, S.A.S, Kuwait Institute for Scientific Research, Kuwait: 137 -147.
15. Palmer, A.R. and Bennett, J. 2013. Degradation of communal rangelands in South Africa: Towards an improved understanding to inform policy. *African Journal of Range and Forage Science* **30** (1-2): 57–63.
16. For example, Kiringe, J.W., Mwaura, F. and Warinwa, F. 2016. Characterization of Chyulu Hills Watershed Ecosystem Services in South-Eastern Kenya. *Environment and Natural Resources Research* **6** (3): 65–76.
17. FAO. 2019. *The State of the World's Biodiversity for Food and Agriculture*. Commission on Genetic Resources for Food and Agriculture, FAO, Rome.
18. Grünewald, C., Schleuning, M. and Böhning-Gaese, K. 2016. Biodiversity, scenery and infrastructure: Factors driving wildlife tourism in an African savannah national park. *Biological Conservation* **201**: 60-68.
19. Davies, J., Poulsen, L., Schulte-Herbrüggen, B., Mackinnon, K., Crawhall, N., et al. 2012. *Conserving Dryland Biodiversity*. IUCN, Gland Switzerland.
20. Gudka, M., Davies, J., Poulsen, L., Schulte-Herbrüggen, B., MacKinnon, K., et al. 2014. Conserving dryland biodiversity: a future vision of sustainable dryland development. *Biodiversity* **15** (2-3): 143–147.
21. Seddon, N., Sengupta, S., García-Espinosa, M., Hauler, I., Herr, D. and Rizvi, A.R. 2019. *Nature-based Solutions in Nationally Determined Contributions: Synthesis and recommendations for enhancing climate ambition and action by 2020.* IUCN and University of Oxford, Gland, Switzerland and Oxford, UK.
22. Chotte, J.L., Aynekulu, E., Cowie, A., Campbell, E., Vlek, P., et al. 2019. *Realising the Carbon Benefits of Sustainable Land Management Practices: Guidelines for Estimation of Soil Organic Carbon in the Context of Land Degradation Neutrality Planning and Monitoring*. UNCCD, Bonn, Germany.
23. Aynekula, E., Suber, M., van Noordwijk, M., Arango, J., Roshetko, J.M. and Rosenstock, T.S. 2020. Carbon storage potential of silvopastoral systems of Colombia. *Land* **9**: 309. doi:10.3390/land9090309.
24. Seddon, N., et al. 2019. *Op cit*.
25. Bardgett, R.D., Bullock, J.M., Lavorel, S., Manning, P., Schaffner, U. et al. 2021. Combatting global grassland degradation. *Nature Reviews Earth and Environment* **2** (10): 720–735.
26. Cornwall, W. 2022. Fiery invasions. *Science* **377** (6606): 568-571.
27. Strömberg, C.A.E. and Staver, A.C. 2022. The history and challenge of grassy biomes. *Science* **277** (6606): 595-593.
28. Carbutt, C., Henwood, W.D. and Gilfedder, L.A. 2017. Global plight of global temperate grasslands: going, going, gone? *Biodiversity Conservation* **26:** 2911-2932.
29. Strömberg, C.A.E and Straver, A.C. 2022. The history and challenge of grassy biomes. *Science* **377** (6606).
30. Gherardi, L.A. and Sala, O.E. 2018. Effect of interannual precipitation variability on dryland productivity: a global synthesis. *Global Change Biology* **25** (1): 269-276.
31. Godde, C.M., Boone, R.B., Ash, A.J., Waha, K., Sloat, L.L. et al. 2020. Global rangeland production systems and livelihoods at threat under climate change and variability. *Environmental Research Letters* **15:** e044021.
32. Brannstrom C. 2009. South America's neoliberal agricultural frontiers: places of environmental sacrifice or conservation opportunity? *Ambio* **38:** 141-149.
33. Cao, S. 2008. Why large-scale afforestation efforts in China have failed to solve the desertification problem. *Environmental Science and Technology* **42** (6): 1826-1831.
34. Ickowitz, A., Slayback, D., Asanzi, P. and Nasi, R. 2015. *Agriculture and deforestation in the Democratic Republic of the Congo: A synthesis of the current state of knowledge.* Occasional Paper 119. Center for International Forestry Research, Bogor, Indonesia.
35. Veldman, J.W. 2016. Clarifying the confusion: old-growth savannahs and tropical ecosystem degradation. *Philosophical Transactions of the Royal Society B* **371** (1703).
36. Buisson, E., Archibald, S., Fidelis, A. & Suding, K.N. 2022. Ancient grasslands guide ambitious goals in grassland restoration. *Science* **377** (594-598)
37. Bastin, J.F., Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., et al. 2019. The global tree restoration potential. *Science* **365**: 76–79.
38. Fernandes, G.W., Serra Cielho, M., Bomfin Machado, R., Ferreira, M.E., Moura de Souza Aguiar, L., et al. 2016. Afforestation of savannas: an impending ecological disaster. *Natureza & Conservação* **14** (2).
39. Bond, W.J. 2019. *Open Ecosystems: ecology and evolution beyond the forest edge*. Oxford University Press, Oxford.
40. Valkó O., Zmiorski, M., Biurrun, I., Loos, J., Labadessa, R. and Venn, S. 2016. Ecology and conservation of steppes and semi-natural grasslands. *Hacquetia* **12**: 5–15.
41. Mansourian, S., Stanturf, J.A., Derkyi, M.A.A., Engel, V.L., 2017. Forest landscape restoration: increasing the positive impacts of forest restoration or simply the area under tree cover? *Restoration Ecology* **25:** 178–183.
42. World Resources Institute. *Atlas of Forest and Landscape Restoration Opportunities.* Washington DC.
43. Veldman, J.W., Overbeck, G.E., Negreiros, D., Mahy, G., Le Stradic, S., et al. 2015. Tyranny of trees in grassy biomes. *Science* **347:** 484-485.
44. Van Oijen, M., Bellocchi, G. and Höglind, M. 2018. Effects of climate change on grassland biodiversity and productivity: the need for a diversity of models. *Agronomy* **8** (14): doi:10.3390/agronomy8020014.
45. Tilman, D., Wedin, D. and Knops, J. 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature* **379**: 718-720.
46. Yang, Y., Tilman, D., Furey, G. and Lehman, C. 2019. Soil carbon sequestration accelerated by restoration of grassland biodiversity. *Nature Communications* **10**: 718.
47. Strassburg, B.B N., Beyer, H.L., Crouzeilles, R., Iribarrem, A., Barros, F., et al. 2018. Strategic approaches to restoring ecosystems can triple conservation gains and halve costs. *Nature Ecology & Evolution* **3** (1): 62–70.
48. Moilanen, A., Anderson, B.J., Eigenbrod, F., Heinemeyer, A., Roy, D.B., et al. 2011. Balancing alternative land uses in conservation prioritization. *Ecological Applications* **21** (5): 1419–1426.
49. Thomas, C.D., Anderson, B.J., Moilanen, A., Eigenbrod, F., Heinemeyer, A., et al. 2013. Reconciling biodiversity and carbon conservation. *Ecology Letters* **16** (SUPPL.1): 39–47.
50. Schmitz, O.J, et al. 2014. Animating the Carbon Cycle. *Ecosystems* **17** (2): 344-359.
51. Holdo, R.M. et al. 2009. A disease-mediated trophic cascade in the Serengeti and its implications for ecosystem C. *PLoS Biology* **7** (9): e1000210.
52. Wang, C.H., Tang, S.M., Wilkes, A., Jiang, Y.Y., Han, G.D. and Huang, D. 2012. Effect of Stocking Rate on Soil-Atmosphere CH4 Flux during Spring Freeze-Thaw Cycles in a Northern Desert Steppe, China. *PLoS ONE* **7** (5): e36794.
53. Reside, A.E., Vanderwal, J. and Moran, C. 2017. Trade-offs in carbon storage and biodiversity conservation under climate change reveal risk to endemic species. *Biological Conservation* **207**: 9-16.
54. Abreu, R.C.R., Hoffmann, W.A., Vasconcelos, H.L., Pilon, N.A., Rossatto, D.R. and Durigan, G. 2017. The biodiversity cost of carbon sequestration in tropical savanna. *Science Advances* **3**: e1701284.
55. Thomas, C.D., et al. 2013. *Op cit.*
56. Soto-Navarro, C., Ravilious, C., Arnell, A., de Lamo, X., Harfoot, M., et al. 2020. Mapping co-benefits for carbon storage and biodiversity to inform conservation policy and action. *Philosophical Transactions of the Royal Society B* **375** (1794).
57. Buisson, E., Archibald, S., Fidelis, A. & Suding, K.N. 2022. Ancient grasslands guide ambitious goals in grassland restoration. *Science* **377** (594-598)
58. Veldmann, J.W., Buisson, E., Durigan, G., Fernandes, G.W., Le Stradic, S., et al. 2015. Towards an old-growth concept for grassland, savannas, and woodlands. *Frontiers in Ecology and Environment* **13** (3): 154-162.
59. Noon, M.L., Goldstein, A., Ledezma, J.C., Roehrdanz, P., Cook-Patton, S.C. et al. 2021. Mapping the irrecoverable carbon in Earth's ecosystems. *Nature Sustainability* **5** 37–46.
60. Buisson, E., Archibald, S., Fidelis, A. & Suding, K.N. 2022. Ancient grasslands guide ambitious goals in grassland restoration. *Science* **377** (594-598)
61. Deng, L., Shangguan, Z.P., Wu, G.L. and Chang, X.F. 2017. Effects of grazing exclusion on carbon sequestration in China's grassland. *Earth Science Reviews* **173**: 84-95.

62. Fedrigo, J.K., Ataide, P.F., Azambuja Filho, J., Oliveira, L.V., Jaurena, M. et al. 2018. Temporary grazing exclusion promotes rapid recovery of species richness and productivity in a long-term overgrazed Campos grassland. *Restoration Ecology* **26** (4): 677–695.
63. Wang, H., Dong, Z., Guo, J., Li, H., Li, J., et al. 2017. Effects of grazing intensity on organic carbon stock in Stipa breviflora steppe vegetation soil systems. *The Rangeland Journal* **39**: 169–177.
64. Byrnes, R.C., Eastburn, D.J., Tate, K.W. and Roche, L.M. 2018. A global meta-analysis of grazing impacts on soil health indicators. *Journal of Environmental Quality* **47:** 758–765.
65. Lipsett-Moore, G.J., Wolff, N.H. and Game, E.T. 2018. Emission mitigation opportunities for savanna countries from early dry season fire management. *Nature Communications* **9:** 2247.
66. Wang, C., Han, G., Wang, S., Zhai, X., Brown, J. et al. 2014. Sound management may sequester methane in grazed rangeland ecosystems. *Scientific Reports* **4:** 4444.
67. Zhu, H., Fu, B., Wang, S., Zhu, L., Zhang, L. et al. 2015. Reducing soil erosion by improving community functional diversity in semi-arid grasslands. *Journal of Applied Ecology* **52**: 1063–1072.
68. Piipponen, J., Jalava, M., de Leeuw, J., Rizayeva, A., Godde, C., et al. 2022. Global trends in grassland carrying capacity and relative stocking density of livestock. *Global Change Biology* **28** (12): 3902–3919.
69. Manning, G.C., Baer, S.G. and Blair, J.M. 2017. Effects of grazing and fire frequency on floristic quality and its relationship to indicators of soil quality in tallgrass prairie. *Environmental Management* **60:** 1062–1075.

For more information

Karina Berg, WWF, karinaberg@wwf.org.br

Nigel Dudley, Equilibrium Research, nigel@equilibriumresearch.com

Jenny Hawley, Plantlife, Jenny.Hawley@plantlife.org.uk